Completed Project (2011 - 2014)

Hypersonic Inflatable Aerodynamic Decelerator (HIAD) Project

Game Changing Development Program | Space Technology Mission Directorate (STMD)

ABSTRACT

Develop an entry and descent technology to enhance and enable robotic and scientific missions to destinations with atmospheres.

ANTICIPATED BENEFITS

To NASA funded missions:

100% increased payload mass (8-10 meter class 2 metric ton) 50% increase in payload mass fraction Access to 90% of Mars surface (Southern Highlands) Eliminates launch shroud constraint (currently approximately 4.5m) on aeroshell diameter

DETAILED DESCRIPTION

The Hypersonic Inflatable Aerodynamic Decelerator (HIAD) project will focus on the development and demonstration of hypersonic inflatable aeroshell technologies suitable for an ISS down-mass capability. The project will focus on the completion of an IRVE 3 development flight test and other necessary analysis and ground-based testing. The key technologies include flexible TPS materials for hypersonic entry conditions, attachment and inflation mechanism and high-strength, lightweight, inflatable bladder materials capable of withstanding high temperatures. The HIAD Project is developing a truly crosscutting technology for atmospheric entry. This technology enhances, and potentially enables, a variety of proposed NASA missions to destinations with atmospheres (Mars, Venus, Titan, the gas giants). This holds true for returning payloads to Earth from Low Earth Orbit (LEO) and beyond, such as ISS down mass or sample return capsules. Not only is this technology applicable to robotic vehicles, the technology is envisioned to be scalable to crewed missions (to Mars or Earth return). The HIAD Project is orchestrating a series of ground and flight tests to demonstrate the viability of thermal resilient materials manufactured in robust configurations to withstand the extreme

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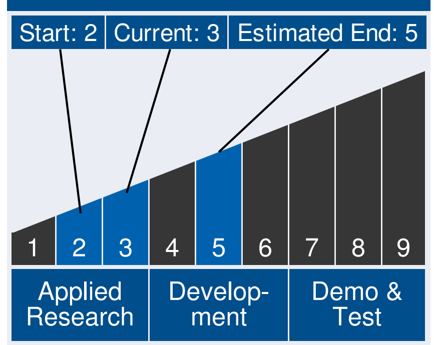
Technology Maturity



Management Team

Program Executive:

- Ryan Stephan

Program Manager:

- Stephen Gaddis

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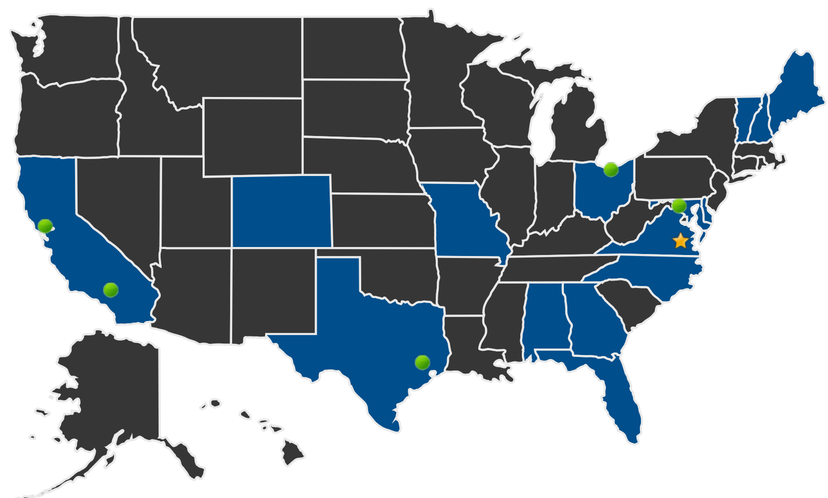
structural and thermal environments experienced during atmospheric entry. Benefits of using the inflatable decelerator design includes mission flexibility provided by the minimal volume and mass requirements to transfer the stowed HIAD to its destination, as well as increased landed mass, accuracy, and altitude in a variety of space applications.

U.S. WORK LOCATIONS AND KEY PARTNERS



U.S. States With Work

Lead Center:
Langley Research Center

Supporting Centers:

- Ames Research Center
- Dryden Flight Research Center
- Glenn Research Center
- Goddard Space Flight Center
- Johnson Space Center

Management Team *(cont.)*

Project Manager:
- Melinda Cagle

Principal Investigator:
- Michelle Munk

Technology Areas

Primary Technology Area:
Entry, Descent, and Landing Systems (TA 9)
└─ Aeroassist and Atmospheric Entry (TA 9.1)
  └─ Thermal Protection Systems for Deployable Decelerators (TA 9.1.2)
    └─ Non-Ablative Concepts for Thermal Protection (TA 9.1.2.1)

Additional Technology Areas:
Entry, Descent, and Landing Systems (TA 9)
└─ Aeroassist and Atmospheric Entry (TA 9.1)
  └─ Deployable Hypersonic Decelerators (TA 9.1.4)
    └─ Inflatable Entry Systems (TA 9.1.4.1)
    └─ Flexible Structural Materials (TA 9.1.4.4)
    └─ Non-Propulsive Flight Control Effectors (TA 9.1.4.5)
    └─ Advanced Guidance and Navigation Systems (TA 9.1.4.6)

Other Organizations Performing Work:

- Airborne Systems
- Aspen Aerogels, Inc. (Northborough, MA)
- Duke University
- Georgia Tech
- ILC Dover
- Lockheed Martin Space Systems Company
- National Institute of Aerospace
- Oceaneering Space Systems
- The Boeing Company
- University of Maine (Orono, ME)
- University of Vermont

DETAILS FOR TECHNOLOGY 1

Technology Title

Hypersonic Inflatable Aerodynamic Decelerator (HIAD)

Technology Description

This technology is categorized as a hardware system for other applications

The Hypersonic Inflatable Aerodynamic Decelerator (HIAD) project will focus on the development and demonstration of hypersonic inflatable aeroshell technologies suitable for an ISS down-mass capability. The project will focus on the completion of an IRVE 3 development flight test and other necessary analysis and ground-based testing. The key technologies include flexible TPS materials for hypersonic entry conditions, attachment and inflation mechanism and high-strength, lightweight, inflatable bladder materials capable of withstanding high temperatures. The HIAD Project is developing a truly crosscutting technology for atmospheric entry. This technology enhances, and potentially enables, a variety of proposed NASA missions to destinations with atmospheres (Mars, Venus, Titan, the gas giants). This holds true for returning payloads to Earth from Low Earth Orbit (LEO) and beyond, such as ISS down mass or sample return capsules. Not only is this technology applicable to robotic vehicles, the technology is envisioned to be scalable to crewed missions (to Mars or Earth return). The HIAD Project is orchestrating a series of ground and flight tests to demonstrate the viability of thermal resilient materials manufactured in robust configurations to withstand the extreme structural and thermal environments experienced during atmospheric entry. Benefits of using the inflatable decelerator design includes mission flexibility provided by the minimal volume and mass requirements to transfer the stowed HIAD to its destination, as well as increased landed mass, accuracy, and altitude in a variety of space applications.

Capabilities Provided

To increase landed mass on Mars as well as other planets, a larger aeroshell is required. HIAD offers a solution. After inflation, HIADs behave like a rigid device. Aerodynamics are scalable and HIADs are lighter, increasing delivered payload. With the reduction in ballistic coefficient through increase in drag area there's deceleration at higher altitudes (aerocapture or entry) leading to reduced heat rates, access to higher elevations for landing, and an increase in landed mass. Figure 1 illustrates a comparison of Mars Science Laboratory (MSL) in red profile and HIAD deployed diameter for similar entry masses in a 4.5m launch shroud.

A mission-ready HIAD will deliver 100% increased payload mass (8-10 meter class 2 metric ton); 50% increase in payload mass fraction; with access to 90% of Mars surface (Southern Highlands). And for payloads returning to earth, with the retirement of the shuttle resulting in the lost capability of returning large payloads from the International Space Station, a HIAD can be used in conjunction with commercial resupply assets to restore that capability. It could even eventually enable the delivery of the 40-60MT payloads required for human exploration of Mars. HIAD has potential for saving billions of dollars for a broad array of reentry missions.

To provide total mission capability, HIAD is working to develop and qualify materials, control mechanisms, and structural design concepts guided by potential mission architectures and to demonstrate performance through ground-based and flight testing at Earth.

The HIAD project has investigated and baselined two different material combinations referred to as Gen-1 and Gen-2. The 10m class Gen-1 HIAD demonstrated 45 Watts/cm^2 heat rate, 7000 Joules/cm^2 heat load, 300 °C back shell temperature, and 5.5 kg/m^2 areal density. The IRVE-3 was a successful flight test of a 5m class Gen-1 HIAD. Gen-2 offers improved thermal performance with less mass. Current estimates for a 10m class Gen-2 HIAD is 65 Watts/cm^2 heat rate, 7500 Joules/cm^2 heat load, 400 °C back shell temperature, and 4 kg/m^2 areal density.

Potential Applications

As the technology matures, HIAD will work toward technology infusion by working with HEOMD and SMD to show how HIAD can be mission enhancing and/or enabling. HIAD will also interact with industry space-access providers with respect to launch vehicle asset recovery.